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# History, Origin and Classification of Persimmon Cultivars

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**Additional index words:** *Diospyros kaki,* taxonomy, astringency, postharvest charactertistics


## Abstract

Persimmons have been produced in China for over two thousand years with some 950 known cultivars currently existing. The majority of persimmons produced around the world are astringent types, but recent trends in breeding programs in China, Japan, Brazil and Europe, and new plantings in many producing countries around the world, show non-astringent types are gaining in popularity. Worldwide, persimmons are available year round as fresh, dried or processed fruit. Persimmons from Israel can be purchased in Hong Kong and Singapore as "Sharon fruit". Dried persimmons from China are available throughout the year in most Asian markets. Australian and New Zealand persimmons are now marketed in a number of Southeast Asian countries. In many Asian cultures persimmons hold special significance and are used in religious offerings during festive seasons. The aim of this review is to provide researchers, extension officers and growers with a clear understanding of the origin, botanical taxonomy, classification of persimmons and the varieties available worldwide.


Persimmons are experiencing the second highest rate of production growth for a tree crop globally. This growth has occurred in Asian and eastern European countries. Global production figures revealed for the years 2002 to 2012 that output increased from approximately 2.6 to 4.5 million tonnes, representing a 66% increase (FAOSTAT, 2014). China is the largest producer of persimmons with 80.2% of world production. The main producing regions are Asia, Europe, the Americas and Oceania (FAOSTAT, 2014). Table 1 provides the production in tonnes on a country basis for the years 2002 to 2012 (FAOSTAT, 2014).

*Asian Region* - China has experienced significant production growth from 1,740,591 tonnes in 2002 to 3,300,000 tonnes in 2012. Korea is the second largest producer after China, increasing from 281,143 tonnes in 2002 to 401,049 tonnes in 2012. Taiwan's production has risen from a base of 34,747 tonnes in 2002 to a production level of 86,000 tonnes in 2012. Nepal's production has increased from 410 tonnes in 2002 to 2,806 tonnes by 2012.

*European region* – Production across European countries has displayed both significant increases and decreases. Italy's production has dropped from a level of 54,170 tonnes in 2002 to 47,000 tonnes by 2012. Israel's production also declined from a peak of 45,350 in 2005 to 31,292 tonnes in 2012, and Slovenia's production dropped from a peak of 805 in 2010 to 681 tonnes in 2012. Over a decade period from 2002, production in Uzbekistan and Azerbaijan increased to 42,500 tonnes and 140,082 tonnes, respectively, in 2012. Key statistics relating to persimmon production levels in Spain and Turkey are not currently available in the FAOSTAT database. However, Llacer and Badenes (2002; 2009) reported Spain's production to be 33,000 tonnes in 2001 and 70,000 tonnes in 2009. Ercisli and Akbulut (2009) reported Turkey's production at 22,000 tonnes in 2008.

*American region* – Brazil is by far the largest producer in the Americas, with production peaking at 173,297 tonnes in

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**Table 1:** Country comparison of production in tonnes as listed in the FAOSTAT from 2002 to 2012.

| Country | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Australia | 866 | 836 | 881 | 943 | 700 | 715 | 720 | 686 | 666 | 642 | 660 |
| Azerbaijan | 104,800 | 114,899 | 48,089 | 108,965 | 124,485 | 128,407 | 132,179 | 135,549 | 142,188 | 146,084 | 140,082 |
| Brazil | 141,364 | 158,131 | 162,288 | 164,849 | 168,274 | 159,851 | 173,297 | 171,555 | 167,215 | 154,625 | 158,241 |
| China | 1,740,591 | 1,795,110 | 1,998,214 | 2,185,041 | 2,320,346 | 2,574,143 | 2,710,988 | 2,834,165 | 2,988,000 | 3,200,000 | 3,300,000 |
| Taiwan | 34,747 | 38,247 | 36,177 | 27,111 | 26,395 | 32,962 | 33,899 | 37,032 | 58,401 | 90,100 | 86,000 |
| Iran | 1,411 | 1,550 | 1,593 | 1,748 | 1,474 | 1,514 | 1,576 | 1,632 | 2,137 | 2,123 | 2,250 |
| Israel | 35,700 | 40,100 | 38,700 | 48,000 | 24,606 | 37,347 | 45,350 | 32,291 | 28,201 | 29,271 | 31,292 |
| Italy | 54,170 | 47,000 | 57,110 | 51,332 | 53,100 | 52,500 | 50,000 | 53,187 | 48,969 | 50,236 | 47,000 |
| Japan | 269,300 | 265,000 | 232,500 | 285,900 | 232,700 | 244,800 | 266,600 | 258,000 | 189,400 | 207,500 | 253,800 |
| Mexico | 192 | 347 | 275 | 369 | 287 | 442 | 362 | 412 | 363 | 223 | 244 |
| Nepal | 410 | 415 | 423 | 443 | 476 | 489 | 509 | 527 | 690 | 1,609 | 2,806 |
| New Zealand | 2,900 | 3,000 | 3,000 | 3,000 | 2,428 | 2,153 | 2,900 | 2,700 | 2,620 | 2,300 | 2,350 |
| South Korea | 281,143 | 249,207 | 299,046 | 363,822 | 352,822 | 395,614 | 430,521 | 416,705 | 390,630 | 390,820 | 401,049 |
| Slovenia | | 550 | 525 | 499 | 398 | 538 | 441 | 569 | 805 | 813 | 681 |
| Uzbekistan | 16,500 | 17,000 | 19,000 | 21,000 | 27,213 | 28,000 | 31,000 | 40,000 | 38,000 | 41,000 | 42,500 |

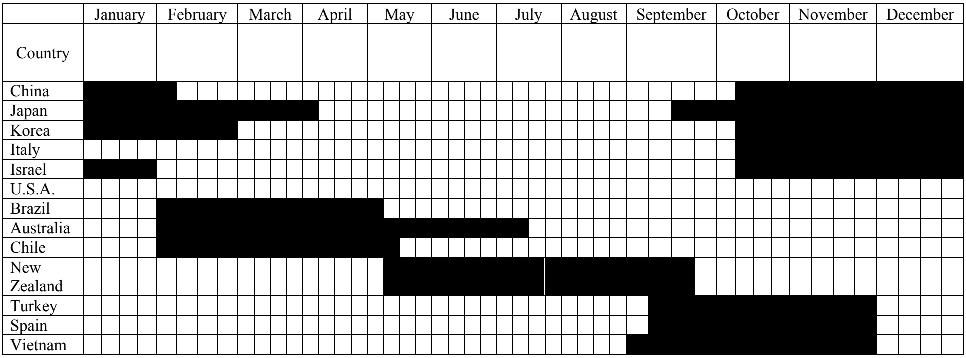
2008 but declining to 158,241 tonnes by 2012. Production in Mexico also decreased from 442 tonnes in 2007 to 244 tonnes in 2012.

*Oceania region* – Production in Australia has declined from 943 tonnes in 2005 to 660 tonnes by 2012. New Zealand's production also reduced from a peak of 3,000 tonnes in 2003 to 2,350 tonnes in 2012. This decline is primarily due to marketing and production issues. The Australian market for persimmons is small and quickly oversupplied. The economics of growing persimmons is influenced by the percentage of production that meets export standards and the overlap of production periods for Australia and New Zealand.

Australia has the longest persimmon season of any country, ranging from February to July (see Fig. 1) (Ercisli and Akbulut, 2009; Giordami, 2002; Nissen et al., 2003). Australian persimmon cultivation, principally the non-astringent types, spans five states, with Queensland producing about 70% of total production. In Australia, the diverse climatic persimmon growing regions extend from the tropical areas of far north Queensland to the temperate regions of Victoria and South Australia. The fruit from the tropical regions mature at least four months earlier than fruit from temperate regions, allowing Australia to have an extended production period compared to other producing countries. The Australian and New Zealand persimmon industries are primarily export oriented.

## Origin and Botanical Classification

The persimmon is believed to have originated in China. Documents from the 5th and 6th centuries on persimmon cultivation in China have been reported on by Grubov (1967), Kikuchi (1948),




Sources: Ercisli and Akbulut (2009), FAOSTAT (2014), George and Nissen (1988), Giordami (2002), Llacer and Badenes (2009), Mowat (1989), Nissen et al. (2003).

**Fig. 1:** Availability of persimmon from producer countries worldwide.

and Sugiura and Subhadrabandhu (1996). The persimmon fruit belongs to the *Ebenaceae* family (flowering plants) and includes ebony and persimmon species. In this family there are approximately 500 species of trees and shrubs that are subdivided into two genera, *Diospyros* and *Euclea*. The *Diospyros* genus has over 400 species of evergreen and deciduous trees, the majority of which grow in the subtropical and tropical regions of Asia, Africa and Central and South America with a few species extending into temperate regions (Cronquist, 1981; Mowat and George, 1994; Ng, 1986; Wagenitz, 1964). *Diospyros kaki* Thunb. was introduced to Japan about 1300 years ago and is a deciduous species adapted to warm temperate regions (Ikegami, 1967; Mowat and George, 1994).

There are several species of *Diospyros* that are of horticultural importance. These are: *Diospyros lotus* L., *Diospyros kaki* Thunb., *Diospyros oleifera* Cheng, *Diospyros virginiana* L., and *Diospyros rhombifolia* Hemsl.. *D. lotus* and *D. oleifera* are cultivated as fruit crops in China with *D. lotus* eaten both as a dried and as a fresh fruit. *D. oleifera* is mainly used for obtaining persimmon oil (tannins). *D. rhombifolia* is an ornamental in China as it bears small attractive-coloured fruit on a dwarf tree (Janick and Paull, 2006). *D. kaki* is also consumed both as a fresh and as a dried fruit in many countries including Japan, Korea, China, Vietnam, Italy, Spain, Portugal, New Zealand, Australia, Brazil and Turkey. *D. virginiana,* the American persimmon alternatively known as the “Eastern persimmon”, is a native of eastern USA and is eaten fresh and used as a rootstock. *Diospyros digyna* Jacq., (syn. *Diospyros ebenaster*) or black sapote, is thought to be native to Central America. *Diospyros discolor* Willd. (syn. *Diospyros blancoi*), also known as velvet apple or mabolo, produces edible fruit of good quality in the Philippines (Janick and Paull, 2006).

## Taxonomy

The botanical name of persimmon is *Diospyros kaki*, but the origin of the name is assigned to Carl Linnaeus (Linneo, Linn or L.), to his son, known as Carl Linnaeus the Younger (L.f.), and to Carl Peter Thunberg (Thunb.); hence in referring to persimmons, the two names commonly used are *D. kaki* L.f. and *D. kaki* Thunb. (Giordani, 2002; Janick and Paul, 2006). *D. kaki* L.f (*D. kaki* Thunb.) is considered to have originated in China (Giordani, 2002). Janick and Paull (2006) indicate that the authority for persimmons should be Thunberg due to his reference to *D. kaki* in the Nova Acta Regiae Societatis Scientiarum Upsaiensis, Vol. 3, p. 284, issued in 1780.

The genus *Diospyros* has four ploidy levels,

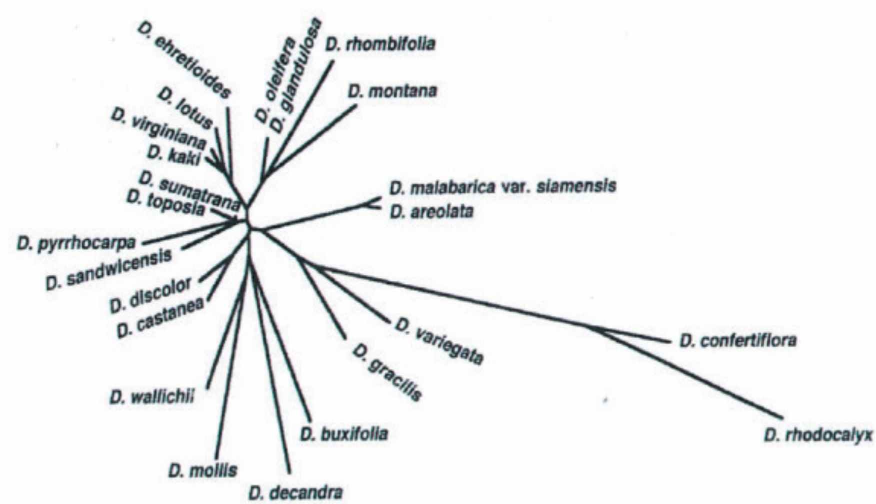



**Fig. 2:** Dendrogram indicating the genetic distances for *Diospyros* species (Yonemori et al., 1998).

diploid (2n = 2x = 30), tetraploid (2n = 4x = 60), hexaploid (2n = 4x = 90) and nonaploid (2n = 9x = 135) with most of the wild species being diploid with a few polyploid, and the cultivated species hexaploid (*D. kaki* and *D. virginiana*) (Somego, 1978; Yonemori et al., 2000).

Ng (1978) indicated that *D. glandulsoa* could be an ancestor of *D. kaki* Thunb. Studies based on cDNA show the relationship of *D. kaki* to *D. glandulsoa, D. lotus* and *D. virginiana* (see Fig. 2) (Yonemori et al., 1998). Chromosonal markers using fluorescent *in situ* hybridization (FISH) and genomic *in situ* hybridization (GISH) showed that the wild species *D. glandulosa* and *D. lotus* and the horticulturally important *D. kaki* are closely related. Choi et al. (2003) used GISH on somatic metaphase chromosomes of *D. kaki,* and showed the *D. glandulsoa* probe hybridised to *D. kaki* resulting in the strongest signal intensity among several wild species of *Diospyros* including *D. oleifera, D. lotus,* and *D. virginiana*. Janick and Paull (2006) suggest that *D. kaki* and *D. glandulsoa* share many common DNA sequences. The chromosome numbers of *Diospyros* species previously reported in the literature are presented in Table 2.

Persimmon, *Diospyros kaki* Thunb, is sometimes called "oriental persimmon" or "Japanese persimmon". It has been a source of food and of cultural significance across the Asian region particularly in China, Korea and Japan (Janick and Paull, 2006). For example, it is used as a traditional fruit for gifting and ancestral offerings in Vietnam. This is recorded in a variety of ancient documents, folk songs and proverbs (Chomchlow, 2004). The Japanese have grown persimmons since ancient times with the selection of superior stock being propagated for hundreds of years (Yakushiji and Nakatsuka, 2007). The Japanese cultivars have been introduced into a number of countries, including USA (California), Italy, Israel, Brazil, Australia and New Zealand (Yonemori et al., 2000).

## Astringency

Persimmon fruit are usually highly astringent. Astringency is the dry, puckering mouth feel that is caused by the tannins in the persimmon fruit. These condensed tannins, polyphenol compounds (proanthocyanidin), cause a rough sandpapery sensation in the mouth. This taste sensation is unpleasant due to coagulation of oral proteins (Denev and Yordanov, 2013). More than 950 cultivars

**Table 2:** Chromosome number of *Diospyros* species.

| Species | Chromosome (2n = 2x =) | Reference |
|---|---|---|
| *D. cathayensis* | 30 | Wang and Wang (1984) |
| *D. comfertifora* | 30 | Ng (1978) |
| *D. decandra* | 30 | Mihoko et al. (1998) |
| *D. discolar* | 30 | Namikawa (1930) |
| *D. ebenum* | 30 | Delay (1947) (cited in Ng (1978)) |
| *D. ehretioides* | 30 | Choi et al. (2003) |
| *D. glandulsoa* | 30 | Somego (1978); Choi et al. (2003) |
| *D. glaucifolia* | 30 | Wang and Wang (1984) |
| *D. kaki* | 90<br>90, 135 | Namikawa and Higashi (1928); Choi et al. (2003); Zhuang et al. (1990; 1992) |
| *D. lotus* | 30 | Namikawa and Higashi (1928); Choi et al. (2003) |
| *D. maingayi* | 30 | Ng (1978) |
| *D. mespiliformis* | 30 | Choi et al. (2003) |
| *D. mollis* | 30 | Mihoko et al. (1998) |
| *D. Montana* | 30 | Ohri and Kumar (1986); Choi et al. (2003) |
| *D. oleifera* | 30 | Wang and Wang (1984); Choi et al. (200)3 |
| *D. rhodocalyx* | 30 | Mihoko et al. (1998); Choi et al. (2003) |
| *D. rhombifolia* | 30<br>60 | Wang and Wang (1984)<br>Choi et al. (2003) |
| *D. sumatrana* | 30 | Mihoko et al. (1998) |
| *D. texana* | 30 | Baldwin and Culp (1941) |
| *D. virginiana* | 90<br>60, 90 | Namikawa (1930); Choi et al. (2003)<br>Baldwin and Culp (1941) |
| *D. wallichii* | 30 | Ng (1978) |

of persimmons exist in China alone (Zhuang et al., 1990), with all being astringent except for one cultivar 'Luo Tian Tian Shi' (Wang at al., 1997). In Japan approximately 50% of all cultivars are astringent (Itamura et al., 2005; Yonemori, 1997). In Korea, of the 186 cultivars collected, the majority are astringent (Kim et al., 1988).

Astringency is due to soluble tannins in the vacuole of the tannin cell. Most persimmons do not lose their astringency when attached, but a few cultivars have been discovered that lose their astringency naturally when on the tree. Practically all astringent cultivars that reach maturation and are harvested will soften and lose their astringency and thus become edible. However, certain cultivars retain their astringency until the soft over-ripe stage. Flesh colouration also occurs in some persimmon cultivars when pollination takes place and seeds develop, leading to the flesh becoming deep red-brown or black in colour. Therefore persimmon cultivars are classified according to the occurrence of pollination, their change in flesh colour, and the persistence of astringency as the fruit develops on the tree.

## Classification of Persimmon Types Based on Fruit Characteristics

*Pollination constant and pollination variant types*

Persimmon cultivars are classified according to their change in flesh colour when pollinated. Where the flesh colour does not change when pollinated these cultivars are called pollination constant (PC) types and when the flesh changes colour or darkens to a deep red-brown or black around the seed when pollinated, are called pollination variant (PV) types.

*Astringent types*

The fruit of these cultivars do not lose their astringency when developing on the tree, but lose their astringency when over-ripe and soft, and are called astringent types. They remain inedible until they become very soft and mushy and do not transport well. Astringent types are also influenced by the presence of pollination (seed) and a change in flesh colour occurs around the seed. Therefore, astringent persimmons are classified into two subgroups, constant-types (PC) and variant-types (PV).

In the pollination constant astringent (PCA) type, the flesh colour does not change and the seeds in the fruit do not produce any volatile compounds. The fruit remains astringent even if they have seeds.

The pollination variant astringent (PVA) types change their flesh colour in the presence of seeds and produce low amounts of volatile compounds. The coagulation of tannins is restricted around the seed, so the astringency remains in the flesh. The flesh around the seed is not astringent where brown spots are present.

*Non-astringent types*

These cultivars will lose their astringency naturally as they develop on the tree and reach maturity. These are called non-astringent types (NA). They are also classified into constant-types (PC) and variant-types (PV). This is dependent upon the relationship between the presence of seeds and flesh colour.

When seeds are present in the flesh of the pollinator variant non-astringent (PVNA) type, the flesh becomes flecked or dark brown in colour as a result of pollination. If the variant-type does not have seeds, the flesh does not turn a dark colour and it will keep its astringency until maturation.

The flesh of the pollinator constant non-astringent (PCNA) type will not change colour and the loss of astringency is not changed with the presence or absence of seeds, but it will keep its astringency until maturation.

*Classifications*

Persimmons are, therefore, classified into four types depending upon the change in flesh colour due to pollination and the presence of astringency (Kitagawa and Glucina, 1984; Yonemori et al., 2000).

i. Pollination variant astringent (PVA)
ii. Pollination constant astringent (PCA)
iii. Pollination constant non-astringent (PCNA)
iv. Pollination variant non-astringent (PVNA)

PVNA persimmon cultivars have a large amount of volatile compounds (acetaldehyde) produced by the seeds during the middle stages of fruit development. This causes coagulation of tannins in the large tannin cells in association with the loss of astringency and darkening of the flesh. However, PVA persimmon cultivars produce low amounts of volatile compounds and the coagulation of tannins is usually restricted to around the seeds, so the astringency remains in the flesh. In PCA cultivars, if they have seeds, no volatiles are produced by the seed and fruit remain astringent (Sugiura et al., 1979).

PCNA persimmon cultivars of Japanese origin naturally lose astringency due to the dilution of tannins as the fruit mature and tannin cells cease development in the early fruit growth stage (Yonemori and Matsushima, 1985; Yonemori et al., 2003).

However the mechanism of the cessation of the tannin cells in PCNA cultivars has never been fully explained. In 2003, Yonemori et al., tested 15 Japanese PCNA cultivars and found that the tannin cells were much smaller than those of non-PCNA cultivars. Tannins of PCNA fruit on trees do not coagulate by ethanol treatment at the immature stage, but those of the other types do. On this basis, Sugiura (1984) proposed a different persimmon classification should be considered to reflect differences in persimmon types based on volatiles by dividing the cultivars between the volatile-dependent group (VDG), which include the non-PCNA types, and volatile-independent group (VIG), which include the PCNA types (Yakushiji and Nakatsuka, 2007).

Therefore, when classifying persimmons based on definitions by Sugiura (1984), using the quality of the tannin in the flesh and the ability of pollination (seeds) to release volatile compounds during fruit development, the classifications are reduced to two.

i. Volatile Independent group (VIG)
ii. Volatile Dependent group (VDG)

*Volatile independent group (VIG)*

Persimmon cultivars in the VIG group are those with the process to naturally lose astringency and are not dependent on the formation and accumulation of volatile compounds in the flesh. This group is comprised of all the PCNA persimmon cultivars.

*Volatile dependent group (VDG)*

Persimmon cultivars in the VDG group are those that naturally lose astringency depending on the formation and accumulation of volatile compounds in the flesh. This group is comprised of all the non-PCNA persimmon cultivars.

## Classification of Persimmon Fruit by Metabolites

Veberic et al. (2010) found secondary metabolites in 11 cultivars of persimmon using a ward method, based on square Euclidian distance, from biochemical data. This classification method is mostly influenced by the predominant sugars in persimmon fruit (fructose and glucose) and total carotenoids in the fruit's skin. Organic and phenolic acids had no important influence on the analysis using this method for classification. However, sugar content directly influences the taste of persimmon cultivars, while carotenoids are a clear visual attribute for consumer preferences (Veberic et al., 2010). The cultivars are categorised into four groups according to their metabolites. These metabolites represent the same groups or classification that corresponds to the four persimmon astringency groups (PVA, PCA, PCNA and PVNA) according to the classifications of both Hume (1914) and Kajiura (1946). The classifications proposed by Hume and Kajiura (PVA, PCA, PCNA and PVNA) are still used today for classification of persimmon types.

## Persimmon Cultivars

Of the four classification types of persimmon, the PCNA types are the most commercially desirable. This is because they lose astringency on the tree and do not require any postharvest treatment to remove astringency. However, there are only a small number of PCNA types commercially available that are highly productive, producing high quality fruit with few defects. Furthermore, the diversity of persimmon germplasm has been narrowed over time, due to a relatively small number of commercially significant cultivars (Sugiura, 2005).

The Japanese PCNA cultivars that lose astringency on the tree have been found to have a qualitative inherited character and a recessive trait controlled by a single gene (Ikeda et al., 1985; Yamada and Sato, 2002). However, 'Luo Tian Tian Shi', a PCNA cultivar discovered in China, has been found to have a dominant trait for astringency loss on the tree (Yakushiji and Nakatsuka, 2007). The use of Chinese PCNA cultivars will now allow breeders of persimmon to overcome inbreeding depression of the PCNA type cultivars. The astringent cultivars have a greater resistance to cold and are grown in more northerly regions of Japan, Korea, China and European countries. In warmer climates, the cultivars 'Fuyu' and 'Jiro' lose their astringency early during the fruit development phase, but in very temperate climates astringency can remain longer in the fruit even until maturity.

In China more than 900 cultivars are known, however only 40 cultivars are planted. All are astringent cultivars with the exception of 'Luo Tian Tian Shi' (Wang et al., 1997). In Japan, 55% of all the production area is cultivated with PCNA types with 31% based on 'Fuyu'. The astringent cultivars 'Hiratanenashi' and 'Tonewase' represent 26% of the total area of production (Yonemori, 1997). In Korea, more than 100 cultivars are known, with most being astringent. Non-astringent cultivar types of Japanese origin now represent 80% of the production in Korea, with 85% of all cultivars grown now being 'Fuyu' (Wong-Doo et al., 2005). In Brazil, the main cultivar grown is also 'Fuyu' and its non-astringent mutations. Some astringent cultivars 'Taubate', 'Rama Forte' (PVA) and local cultivars 'Chocolate' and 'Manteiga' are also grown (Llacer and Badenes, 2002).

Persimmon production in the Mediterranean is essentially based on 'Kaki Tipo', 'Rojo Brillante' and 'Triumph' (Llacer and Badenes, 2002). In Portugal, the most important cultivar grown is 'Coroa de Rei' and other cultivars grown are 'Triumph', 'Hana Fuyu' and 'O'Gosho', but 'Rojo Brillante' is gaining in popularity (Llacer and Badenes, 2002). In Spain, 'Rojo Brillante' is now being grown in many of the traditional persimmon growing areas. In the Cataluña region of Spain, the main cultivar is 'Gordo', but this cultivar is under threat from 'Rojo Brillante' (Giordani, 2002; Llacer and Badenes, 2002). In Italy, 90% of persimmon production is based on 'Kaki Tipo' but the appearance of the Spanish selection 'Rojo Brillante' has undermined the acceptance of 'Kaki Tipo' in the European market (Giordani, 2002). This is due to 'Rojo Brillante's excellent taste, attractiveness, consistent quality and very high productivity. In Israel, 95% of the production is based on 'Triumph'.

In Australia, persimmon production is primarily based on two non-astringent cultivars 'Fuyu' and 'Jiro'. In New Zealand, 'Fuyu' is the most important cultivar (Nissen et al., 2003). For Vietnam, production is based primarily on local astringent cultivars. In northern Vietnam the major cultivars in production are 'Thach That', 'Nhan Hau' and 'Luc Yen'. In central and southern regions of Vietnam, production is based on 'Trung Loc', 'Vuong' (Tam Hai) and 'Vuong' (Ong Dong) (unpublished). A listing of the country of origin for the major commercial persimmon cultivars of Asia and several Mediterranean countries is given in Table 3 and the genetic origin of Japanese persimmon cultivars in Table 4.

## Postharvest Handling of Persimmon Cultivars

Non-astringent persimmon cultivars offer significant advantages over astringent cultivars in warm temperate regions of the world. Astringent cultivars need the astringency to be removed before eating (Janick and Paull, 2006). Naturally allowing the fruit to soften reduces the level of astringency, therefore transportation and storage of this soft fruit presents a range of difficulties. To overcome this problem, in many of the Asian countries, astringent persimmon fruit are cured, dried and dehydrated naturally. The natural drying process increases the sugar concentration in the fruit due to water loss. The fruit also lose their round full shape by pressing and excellent skin colour due to peeling, but it is sold without any difficulty of damage or rapid deterioration in quality (Ang et al., 1999).

Astringency removal methods presently used cause the fruit to soften and result in the fruit being difficult to market. Globally the most popular commercial method to remove astringency is by carbon dioxide treatment. Astringent fruit are exposed to 90-100%

**Table 3a:** Country of origin of the major commercial persimmon cultivars: Japan.

| Cultivars of Japanese origin | Type | Cultivars of Japanese origin | Type | Cultivars of Japanese origin | Type |
|---|---|---|---|---|---|
| Aizumishirazu | PVA[1] | Kanshu | PCNA | Tsru Maghari | PVA |
| Akagaki | PVNA | Maekawa Jiro | PCNA | | |
| Amankaki | PVNA | Matsumotowasefu yu | PCNA (Bs) | Uenishi-wase | PCNA (Bs) |
| Atago | PCA | Mikado | PCNA | | |
| Ama Hyakume | PVNA | Mikatani Gosho | PVNA | Watarizawa | |
| Amayotsumizo | | Monpei | | Yubeni | PCNA |
| Aisyuhou | PCNA | Mushiroda Gosho | PCNA | Yotsumizo | PCA |
| Cal Fuyu | PCNA (1) | Miyazakitanenashi | | Youhou | PCNA |
| Compact Hiratanenashi | PCA | Mizushima | PVNA | Yokono | PCA |
| Emon | PVA | Mushirodagosho | | Yamato Saijo | PCA |
| | | Nishimura Wase | PVNA | Yamato Gosho | PCNA |
| Fuji | PCA | Ohtanenashi | PVA | Yamato | PCA |
| Fuyu | PCNA (1) | Oku Gosho | PCNA | Yoho | PCNA |
| Fujiwara Gosho | PCNA | O'gosho | PCNA | Yemon | PVA |
| Giambo | | Omiya Wase | PVNA | | |
| Gosho | PCNA | Ooniwa | | Zenjimaru | PVNA |
| Hyakume | PVA | Otanenshi | | | |
| Hachiya | PCA | Okame | PVA | | |
| Hana Fuyu (?) (syn. Yotsundani) | PCNA (1) | Sunami | PCNA | | |
| Huashi | PVA | Shinshu | PCNA | | |
| Hiratanenashi | PCA | Soshu | PCNA | | |
| Hana Gosho | PCNA | Sakoumiathan | PCA | | |
| Haze Gosho | PCNA | Shakoushi | PCA | | |
| Hagakushi | PCA | Shogatsu | PVNA | | |
| Ichikikei Jiro | PCNA | Suruga | PCNA | | |
| Izu | PCNA | Saijo | PCA | | |
| Ichidagaki | PCA | Sakushumishirazu | | | |
| Jiro | PCNA | Sugitawwase | PVA | | |
| Jirou | PCNA | Tamopan | A | | |
| Kyi joh | PCNA | Tenryubou | | | |
| Koda Gosho | PCNA | Taishu | PCNA | | |
| Kaki Tipo | PVNA | Tone Wase | PVA | | |
| Kazusa | PCNA | Tanrei | PCNA (O) | | |
| Koshu Hyahune | PVA | Tenjin Goshs | PCNA | | |
| Kikuhiru | | Tone Wase | PCA | | |
| Kyara | | Triumph | PCA | | |
| Kishu | PCNA (O) | Tanbawase-Fuyu | PCNA | | |
| Kohshimaru | PVA | Tsurugaki | PVA | | |

carbon dioxide for 24 hours at a constant temperature of 25°C. Fruit are then kept in air for 24 to 48 hours at 20°C to ensure complete coagulation of the tannin (Toye et al., 1987). Ethylene vapour may be used to hasten the coagulation of tannin in the fruit.

Persimmon fruit produce little ethylene but are highly sensitive to ethylene, therefore another popular method to remove the astringency is through ethanol application. On-tree astringency removal has also been carried out in Japan by enclosing individual fruit in a polyethylene bag containing a small block of ethanol gel. After one or two days,

**Table 3b:** Country of origin of the major commercial persimmon cultivars: China and Unknown.

| Cultivars of Chinese origin | Type | Cultivars of Chinese origin | Type | Cultivars of Unknown origin (Suggested Country of origin) | Type |
|---|---|---|---|---|---|
| Anguyoushi | PCA | Licheng Mianshi | | Twentieth Century | PCNA |
| Anxi Youshi | | Luotian Tanshi | | Imoto (Bs) | PCNA |
| Baogai-tianshi | PCNA | Mianrangshi | | Gailey | PVA |
| Changanmiandanshi | | Mopanshi | PCA | Maru | |
| Chekiang persimmon | | Oily Persimmon | | Lawford (Australia ?) | A |
| Dahongshi | PCA | | | Kingcot (Australia ?) | A |
| Dayeshuishi | | Qujing Shuishi | | Pomelo 6-22 (Australia ?) | A |
| Eshi 1 | PCNA | Qiuyan | | Pitman Selection (Australia ?) | A |
| Ehuangshi | | Qiyuezao | PCA | Charming (Australia ?) | A |
| Guanguanshi | | Sifang-tianshi | PCNA | Titibut | A |
| Gongcheng Niuxinshi | | | | Nightingale | A |
| Gail | PCA | | | Dia Dia Maru | PVA |
| Gongcheng-shuishi | PCA | Sanyuan Shaoshi | | Lycoperscion | A |
| Gaojiaofangshi | PCA | Shagu-01 | | Flat Seedless (Australia ?) | A |
| Guangzhou Dahongshi | | Shiyangshi | | Delicious (Australia ?) | NA |
| Hojin | PCA | Tongpenshi | PCA | Fuyu Hana | |
| Huashi No 1 | PCNA | Taiwan Zhengshi | | Rynerson (Australia ?) | |
| Heze Bayuehuang | | Xioyiniiuxinshi | PCA | Honan Red (USA ?) | A |
| Huaitaishi | | Xiaobaogai-tinshi | PCNA | Korokuma (Australia ?) | A |
| Hangzhou Niuxinshi | | Xiangxi-tianshi | PCNA | | |
| Heixinshi | | Xiaoguotianshi | PCNA | | |
| Jiuyueqing | | Xiaogaishi | | | |
| Jixinhuang | PCA | Xiangyang Niuxinshi | | | |
| Jumishi | PCA | | | | |
| Jinshi | | Yuduheshi | PCA | | |
| Jinzaoshi | | Zhejiang Yeshi | | | |
| Luotiantianshi | PCNA | Zhouquhuoshi | | | |
| Luo Tian Tian Shoi | PCNA | | | | |
| Louhe | | | | | |
| Laoshigou | | | | | |
| Laopige | | | | | |
| Licheng Fangshi | | | | | |

the fruit will completely lose its astringency (Janick and Paull, 2006; Kader, 2002).

The use of 1-MCP (1-methylcyclopropene) will be critical if astringent cultivars are grown in Australia. This is a very effective inhibitor of the ethylene reaction in the fruit, the primary cause of fruit ripening and softening. 1-MCP may have to be used in combination with astringency removal methods to allow astringent fruit types to be transported and stored (Redpath et al., 2009).

**Table 3c:** Country of origin of the major commercial persimmon cultivars: Spain, Italy and Republic of Korea

| Cultivars of Spanish origin | Type | Cultivars of Italian origin | Type | Cultivars of Korean origin | Type |
|---|---|---|---|---|---|
| Aneka | PCA | Brazzale | | Bongok | PCA |
| Betera-1 | PVA | Chocolate | | Changzunshi | |
| Betera-2 | PVA | Cioccolatino | | Chohongsi | PCNA |
| Betera-3 | PVA (3) | Costata | | Chohonshi | PCA |
| Burriana | PVA (1) | Lampadina | | Chondobanshi | PVA |
| Constanti | PVNA | Moro | | Daen Dangam | PCNA |
| Cristalino (A)? | PVA (4) | Melella | | Shagu-01 | |
| Cristalino (B) | PCA (4) | Mandarino | | Weohasi | PCA |
| Enguera 1 | PCA (2) | Mercatelli | PVNA | | |
| Enguera 2 | PVA (1) | Rispoli | | | |
| Enguera 3 | PCA | Vanigila | PVNA | | |
| Ferrran 12 | PVA | Zellona | | | |
| Garidells | PCA (2) | | | | |
| La Selva | PVNA | | | | |
| Mercatelli | (4) | | | | |
| Picudo | PCA (3) | | | | |
| Reus 6 | PCA | | | | |
| Reus 15 | PVA | | | | |
| Rojo Brillante | PVA (4) | | | | |
| Tomatero | PCA | | | | |
| Tamamoto | PCA | | | | |
| Vaniglia | (4) | | | | |
| Xato | PVA (1) | | | | |
| Xato Bonrepos | PVA | | | | |

A = Astringent; NA = non-astringent; PCNA = Pollination constant non-astringent; PVNA = Pollination variant non-astringent; PCA = pollination constant astringent; PVA = Pollination varient astringent.
(O) - Ornamental persimmon.
(1), (2), (3), (4) - RAPD marker work by Badenes et al. (2002) suggests that these cultivars may be identical.
(Bs) Bud sport or mutation.

## Conclusions

Global production for persimmon fruit has increased over the last decade evidenced by significant growth in the three leading countries of China, South Korea and Japan. However, there has been a decline in other countries due to production and postharvest issues (pest and disease pressures and physiological disorders) and the imposition of export market standards. Approximately 80% of the world production is based on the cultivar 'Fuyu'. There is a worldwide trend towards the use of non-astringent cultivars except for the cultivar 'Rojo Brillante' from Spain, which is increasing in popularity in the Mediterranean.

Taxonomy studies have shown how the diversity of persimmon germplasm has been narrowed over time. New taxonomy studies are now providing a way forward to improve fruit quality and eliminate inherent traits, such as basal cracking, concentric ring cracking and calyx separation. However, to date, there has been very little work carried out on rootstocks to determine the effects on fruit quality, precocity and tree size control.

The extra handling processes to remove the astringency (for example, costs of the chemical products; special treatment and ripening rooms or containers) that contribute to increased postharvest handling and marketing costs have not yet been fully examined. Further research is needed, regarding the four classified types of persimmon, to identify the added costs required by the astringency removal method on the production process.

**Table 4:** Genetic origin of Japanese persimmon cultivars.

| PCNA cultivar name | Genetic origin of bud sport or mutation or parents of cultivar |
|---|---|
| 'Imoto' | Possibly bud sport of 'Jiro' |
| 'Uenishiwase' | Bud Sport of 'Matsumotowase Fuyu' |
| 'Sunami' | Bud Sport of 'Fuyu' |
| 'Aisyuhou' | Bud Sport of 'Manekawa-Jiro' |
| 'Tanbawase-Fuyu' | Bud Sport of 'Fuyu' |
| 'Kyi-joh' | Bud Sport of 'Matsunotowase Fuyu' |
| 'Tone Wase' | Bud Sport of 'Hiratanenashi' |
| 'Ohtanenashi' | Bud Sport of 'Hiratanenashi' |
| 'Kohshimaru' | Bud Sport of 'Hiratanenashi' |
| 'Suruga' | Cross 'Hana Gosho' X 'Oku Gosho' |
| 'Izu' | Cross 'Fuyu' X 'Okitu-1' ('Okugosho' X 'Okugosho') |
| 'Shinshu' | Cross 'Okitsu-20' ('Fukurgosho' X ''Hanagosho') X Okitsu-1 ('Okugosho' X 'Okugosho') |
| 'Youhou' | 'Fuyu' X 'Jiro' |
| 'Taishu' | 'Fuyu' X 'IIiG-16' ['Jiro' X 'Okitu-15'('Okugosho' X 'Hanagosho') |
| 'Yubien' | 'Matsumotowase-Fuyu' X F-2 ('Jiro' X 'Okughosho') |
| 'Sohu' | 'Izu' X 109-27 ['Okitsu-2'('Fuyu' X Okugosho') X 'Okitu-17' ('Okugosho' X 'Fukurgosho')] |
| 'Kanshu' | 'Shinshu' 318-4 ['Fuyu' X 'Okitu-16'('Okughosho' X 'Hanagosho') |
| 'Kishu' | Izu' X'Akitsu-5 ['Fuyu' X 'Okitu-16'('Okughosho' X 'Hanagosho') |

Sources: Janick and Paull (2006), Badenes et al. (2002)

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